DETAILED ACTION

1. Receipt of the papers filed on July 9, 2008, is acknowledged. New claim 40 has been added. Claims 1, 3-5, 7, 8, 11-15, 17-22, 24-26 and 28-40 are pending.

2. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

Claim Rejections - 35 USC § 103

3. Claims 1, 3-5, 7, 8, 11-15, 17-22, 24, 25, 28-31, 33-37, 39 and 40 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dubin et al (5,972,192) combined with either Ueno (6,245,676) or Jernstedt et al (2,678,909) and further in view of Ding et al (5,328,871) with either Sonnenberg et al (5,223,118) or Creutz (3,770,598) for the reasons of record and in view of the comments below under the heading "Response to Arguments".

4. Claim 32 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dubin et al (5,972,192) combined with either Ueno (6,245,676) or Jernstedt et al (2,678,909) and further in view of Ding et al (5,328,871) with either Sonnenberg et al (5,223,118) or Creutz (3,770,598) as applied to claims 1, 3-5, 7, 8, 11-15, 17-22, 24, 25, 28-31, 33-37, 39 and 40 above, and additionally in view of in view of Ting et al

(5,969,422) for the reasons of record and in view of the comments below under the heading "Response to Arguments".

5. Claim 38 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dubin et al (5,972,192) combined with either Ueno (6,245,676) or Jernstedt et al (2,678,909) and further in view of Ding et al (5,328,871) with either Sonnenberg et al (5,223,118) or Creutz (3,770,598) as applied to claims 1, 3-5, 7, 8, 11-15, 17-22, 24, 25, 28-31, 33-37, 39 and 40 above, and additionally in view of Uzoh et al (6,251,251) for the reasons of record and in view of the comments below under the heading "Response to Arguments".

6. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dubin et al (5,972,192) combined with either Ueno (6,245,676) or Jernstedt et al (2,678,909) and further in view of Ding et al (5,328,871) with either Sonnenberg et al (5,223,118) or Creutz (3,770,598) as applied to claims 1, 3-5, 7, 8, 11-15, 17-22, 24, 25, 28-31, 33-37, 39 and 40 above, and additionally in view of Dubin et al (6,491,806), newly cited.

7. Claim 26 has been amended to recite that the organic additive does not include a leveling agent. The term "leveling agent" as used by applicant in claim 26 is interpreted as including the compounds at page 12, line 29 to page 13, line 8 of

applicant's specification. At page 12 of the specification, applicant indicates that the term "organic additives" includes suppressor agents and that examples of suppressor agents include polyethylene glycols and polyoxyethylene glycols. The Dubin et al '806 patent is directed to an electroplating bath composition for electroplating copper into recesses to form interconnects in microelectronic devices with reduced incidence of voids. See the abstract. Dubin et al '806 disclose that the electroplating bath may include suppressor agents (column 4, lines 21-59). In one embodiment, the suppressor agent may be a glycol such as polyethylene glycol (column 4, lines 33-37). This is the same compound disclosed by applicant. In other embodiments, the suppressor agent may be a cross-linked polyamide (column 4, lines 26-32) or a polyamine (column 4, line 55). Dubin et al '192 discloses that the organic additive may be a polyamide or a polyamine (column 6, lines 18-19). As shown by Dubin et al '806, these compounds are suppressor agents which are equivalent to the polyethylene glycol used by applicant as a suppressor agent. Since the polyamides and polyamines used by Dubin et al '192 can be identified as suppressor agents and used as equivalents of polyethylene glycol as shown by Dubin et al '806, they are not considered to be excluded by the wording of claim 26 as amended.

8. Claims 1, 3-5, 7, 8, 11-15, 17, 20-22, 24-26, 28-31, 33-37, 39 and 40 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ueno (6,245,676) in view of Dubin et al (6,491,806) or Mayer et al (6,946,065).

9. The Ueno patent is directed to electroplating copper into recesses such as trenches to form interconnects on a semiconductor workpiece. The workpiece is exposed to an electroplating bath containing copper to be deposited and an additive which functions as a retarding agent (column 9, lines 7). This corresponds to step (a) of applicant's independent claims 1, 24, 25 and 26. In one embodiment illustrated in figure 4, a pulsed forward current is applied to the workpiece until the trenches are filled (buried). This corresponds to step (b) of applicant's claims 1, 24, 25 and 26. After the trenches are filled, Ueno discloses applying a forward-reverse pulsed current for removing additive molecules. This corresponds to step (c) of applicant's claims 1, 24, 25 and 26.

10. Applicant's claim 1 differs from the process of Ueno by reciting that the additive comprises an accelerator agent, while Ueno discloses an additive which retards, i.e., a suppressor additive.

11. As noted above, the Dubin et al '806 patent is directed to an electroplating bath composition for electroplating copper into recesses to form interconnects in microelectronic devices with reduced incidence of voids. See the abstract. The bath of Dubin '806 includes a source of copper, at least one acid such as sulfuric acid, at

least one halogen ion, and at least on additive selected from an accelerating agent, a suppressing agent, and an accelerating-suppressing agent (column 2, lines 31-38). The halogen may be chlorine (column 3, lines15-22). The at least one additive may include binary combinations such as an accelerating agent and a suppressing agent (column 3, lines 34-35). The accelerator may be a mercapto compound such as 3-mercapto-1-propanesulfonic acid (column 3, lines 40-51). The suppressor may comprise a cross-linked polyamide or a glycol such as polyethylene glycol (column 4, lines 21-37). Distinct advantages are realized with the disclosed electroplating bath composition. The amount of defects in the form of voids is reduced and filling of the recesses is more complete. See column 8, lines 13-21.

12. The Mayer et al patent is directed to electroplating metal into recessed features. The process facilitates bottom-up filling. See the abstract. The invention is concerned chiefly with the filling of small, recessed features typically having high aspect ratios (column 9, lines 11-12). The filling of high aspect ratio features is performed by bottom-up filling where electrically conductive material preferentially deposits onto the bottoms of the features, and the formation of seams and voids is reduced or avoided (column 10, lines 60-67). The plating bath contains the metal to be plated which may be copper provided by copper sulfate dissolved in an aqueous solution of sulfuric acid. The bath additionally contains organic additives (column 8, lines 19-31). The additives are of three general types, suppressors, accelerators

and levelers. Suppressor additives retard the plating reaction. Typical suppressors are large molecules, for example polymers. The bath often contains ppm level of chloride ions which are required for the suppressors to be effective. Accelerator additives accelerate the plating reaction. Accelerators may be rather small molecules. Levelers behave like suppressors but tend to be more electrochemically active than suppressors and typically are consumed during plating. See column 8, lines 32-61. Additives may be used singly or in combination (column 18, lines 24-25).

13. The prior art of record is indicative of the level of skill of one of ordinary in the art. It would have been obvious to have utilized a plating bath as disclosed by Dubin et al '806 or Mayer et al in the process of Ueno because these baths are formulated to promote bottom-up filling of high aspect ratio recesses, such as the recesses being filled by Ueno. Both Dubin et al 806 and Mayer et al disclose baths which include an accelerator additive, as recited in instant claim 1, as well as a suppressor additive as disclosed by Ueno.

14. With respect to claim 3 Ueno discloses the use of alternating pulses of forward and reverse power during the second time period.

15. With respect to claims 4 and 5, Ueno discloses that t_1 and t_2, the duration of pulses, is set within about 10 seconds (column 10, lines 13-15). This time period overlaps the ranges recited by applicant. See MPEP 2144.05.

16. With respect to claim 7, time is a result-effective variable, and the choice of an appropriate amount of time to carry out the second stage of the process of Ueno would have been a matter of routine optimization.

17. With respect to claims 8 and 22, the electroplating power used in both the second and third time periods may include forward and reverse pulses. A portion of the second stage of the Ueno process may be regarded as a second time period while a different portion may be regarded as a third time period.

18. With respect to claims 11, 12 and 39, current and voltage are result-effective variables. Choice of appropriate values to fill the recesses of Ueno in a void-free manner would have been a matter of routine optimization. Ueno teaches that the current pattern can be altered to prevent any void from being produced (column 16, lines 19-23).

19. With respect to claims 13 and 40, Ueno discloses the deposition of copper.

20. With respect to claim 14 and 15, as indicated above, both Dubin et al '806 and Mayer et al disclose baths that contain copper and sulfate ions, and teach the inclusion of the chloride ion.

21. With respect to claim 17, Dubin et al '806 discloses the use of 3-mercapto-1-propane sulfonic acid as an accelerator agent (column 4, lines 7-11). Mayer et al similarly disclose use of a mercaptopropane sulfonic acid as an accelerator (column 15, lines 25-30).

22. With respect to claims 20 and 21, Dubin et al '806 discloses the use of polyethylene glycol as a suppressor agent (column 4, lines 33-37). Mayer et al also disclose the inclusion in the copper electroplating bath of polyethylene glycol as a suppressor (column 15, lines 30-32).

23. With respect to apparatus claims 28-31, Ueno discloses the use of fountain plating apparatus which is illustrated in figure 11. The apparatus includes a reactor 23, and an unnumbered anode shown in contact with the plating bath and attached to a line with a (+) symbol. The silicon substrate 11 is shown as being attached to a line with a (-) symbol and would function as the cathode during use of the apparatus. The figure does not depict a power supply or controller. Nevertheless, a power supply and controller would necessarily have been present to have produced the electrical waveforms illustrated in figures 3-6. As shown figures 3-6, the apparatus of Ueno would have been operable in the manner recited in claims 29-31 and 37.

24. With respect to claim 32, figure 1c of Ueno shows that deposition takes place on the surface and within the recessed microstructures.

25. With respect to claims 33-36, Figure 4 of Ueno shows the inclusion of periods of off power between pulses of forward and reverse power.

26. Claims 18 and 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ueno (6,245,676) in view of Dubin et al (6,491,806), newly cited, or Mayer et al (6,946,065) as applied to claims 1, 3-5, 7, 8, 11-15, 17, 20-22, 24-26, 28-31, 33-37, 39 and 40 above, and further in view of Sonnenberg et al (5,223,118).

27. Claims 18 and 19 additionally differ from the process of Ueno by reciting inclusion of a leveler in the electroplating bath. As noted above, Mayer discloses that there are three types of additives, one of which is levelers. Mayer does not disclose specific leveler compounds. The Sonnenberg patent is directed to analyzing organic additives, such as brighteners and levelers, in an electroplating bath. Sonnenberg discloses that levelers that may be added to the bath include those which contain a N-R_1-S group, where R_1 may be an alkyl or aryl group (column 6, lines 15-19). It would have been obvious to have included a leveler agent with the chemical structure N-R_1-S in the process of Ueno because these agents are useful in leveling deposits as shown by Sonnenberg et al.

28. Claim 38 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ueno (6,245,676) in view of Dubin et al (6,491,806), newly cited, or Mayer et al (6,946,065) as applied to claims 1, 3-5, 7, 8, 11-15, 17, 20-22, 24-26, 28-31, 33-37, 39 and 40 above, and further in view of Uzoh et al (6,251,251)

29. Claim 38 additionally differs from the apparatus of Ueno by reciting a diffuser plate between the anode and the location of the workpiece.

30. The Uzoh patent is directed to apparatus for electroplating onto semiconductor wafers. As shown in figure 1, the apparatus includes diffuser plate 11 between anode 3 and the position of the workpiece. Uzoh et al teach that the diffuser plate redistributes the flow from a non-uniform pattern to a more uniform pattern or to that of some intended flow pattern (column 3, lines 6-9). It would have been obvious at the time the invention was made to have included a diffuser plate in the apparatus suggested by Dubin et al and Ueno because flow of the electrolyte would have been better controlled.

Response to Arguments

31. Applicant's Remarks have been carefully considered but are not deemed to be persuasive. At page 18 of the Remarks, applicant observes that Dubin does not so much as contemplate the phenomenon of "momentum plating." While this observation may be correct, Dubin suggests the basic process steps recited by applicant. The fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

32. Beginning at the bottom of page 18, applicant discusses an embodiment of the Dubin process in which copper is electroplated to a thickness of about one half of the opening width using forward-reverse plating, and then the thickness of the deposited copper is reduced by anodic dissolution by employing anodic dc or pulse current. Applicant argues on page 19 that the recess would be filled to about 16% of its depth after the first plating step, and that Dubin fails to teach or suggest reversing the electroplating power for at least a portion of a second time period when the fill in the recessed microstructures is at or near the point of planarization. This argument is not convincing with respect to applicant's claims as amended. Dubin discloses more than one embodiment. At column 6, lines 28-34 Dubin states "In another embodiment of the present invention, forward-reverse pulse plating is employed to electroplate Cu or a Cu alloy in substantially voidlessly filling a high aspect ratio opening from an electroplating solution containing a leveling agent. An optional brightening agent can also be incorporated in the electroplating composition for improved uniformity." Applicant's claim 1 recites in step (a) exposing the workpiece to an electroplating bath including a source of metal ions and an organic additive which comprises an accelerator agent. As noted, Dubin discloses plating from a bath containing a source of copper and a brightening agent. As explained in the office action of September 21, 2007, Ding et al shows that the terms brightener and accelerator are used interchangeably. Thus, the bath of

Dubin includes an organic additive comprising an accelerator agent as recited by applicant. Applicant's claim 1, step (b) recites supplying net forward electroplating power. The expression "net forward electroplating power" includes the forward-reverse pulse plating power used by Dubin. Applicant's claim 1, step (c) recites reversing the electroplating power supplied for at least a portion of a second time period. This step also includes the forward-reverse pulse plating power used by Dubin. Applicant's claim 1, step (c) now recites reversing the electroplating power when the fill in the recessed microstructures is at or near the point of planarization. In interpreting this limitation, the point of planarization is taken to be the point at which the fill reaches the top of the microstructures. The embodiment of Dubin using forward-reverse pulse plating at column 6, lines 28-34 may be considered to include two time periods. The first time period may be taken to be the time it takes for the metal being deposited in the recesses to reach a point near the top of the recess, for example, about 85% full. The second time period may be taken to be the time it takes to complete the deposition process. Thus, Dubin may be interpreted as suggesting the steps of supplying net forward electroplating power for a first time period and reversing the electroplating power for at least a portion of a second time period as recited in applicant's claims.

33. At the bottom of page 19 to the top of page 20, applicant argues that Dubin '192 fails to suggest an electroplating bath where the organic additive includes an

accelerator but not a leveling agent as recited in claim 26 as amended. This argument has been addressed above in the new ground of rejection additionally based on Dubin et al '806.

34. At page 20 of the Remarks, applicant argues that there is no apparent reason to combine Dubin and Ueno because the suggested combination would change the basic principle under which Dubin was designed to operate, that is, using a reverse pulse plating step to partially dissolve the copper structure. This argument is not persuasive. Ueno teaches that reverse electroplating power assists in removing any corner of an opening of a trench to prevent any pinch-off. See column 9, lines 26-31. Dubin states that the thickness of the deposited copper is reduced by anodic dissolution (i.e., reverse electroplating power) to have about the same or smaller Cu thickness at the corners of openings than that on the side walls. Thus, Ueno and Dubin disclose the use of reverse electroplating power for the same reason.

35. At page 21 of the Remarks, applicant additionally argues that Ueno still fails to teach or suggest reversing electroplating power for at least a portion of a second time period when the fill in the recessed microstructures is at or near the point of planarization to substantially desorb accelerator agent from the deposited metal structure. This argument is not convincing since Ueno shows in figure 4 applying reversed electroplating power after the recessed trenches have been filled to remove additive molecules. Applicant additionally argues that Ueno teaches that it is

desirable, not undesirable, to form an overburden over recessed microstructures. While this may be correct for some embodiments, Ueno also teaches that "the current pattern conducted until a substantially flat copper plated layer is deposited is not needed to be fixed" indicating that the process may produce a substantially flat layer. See column 16, lines 19-23.

36. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to WILLIAM T. LEADER whose telephone number

is (571) 272-1245. The examiner can normally be reached on Mondays-Thursdays and alternate Fridays, 7:30-4:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Susy Tsang-Foster can be reached on 571-272-1293. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

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October 9, 2008
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